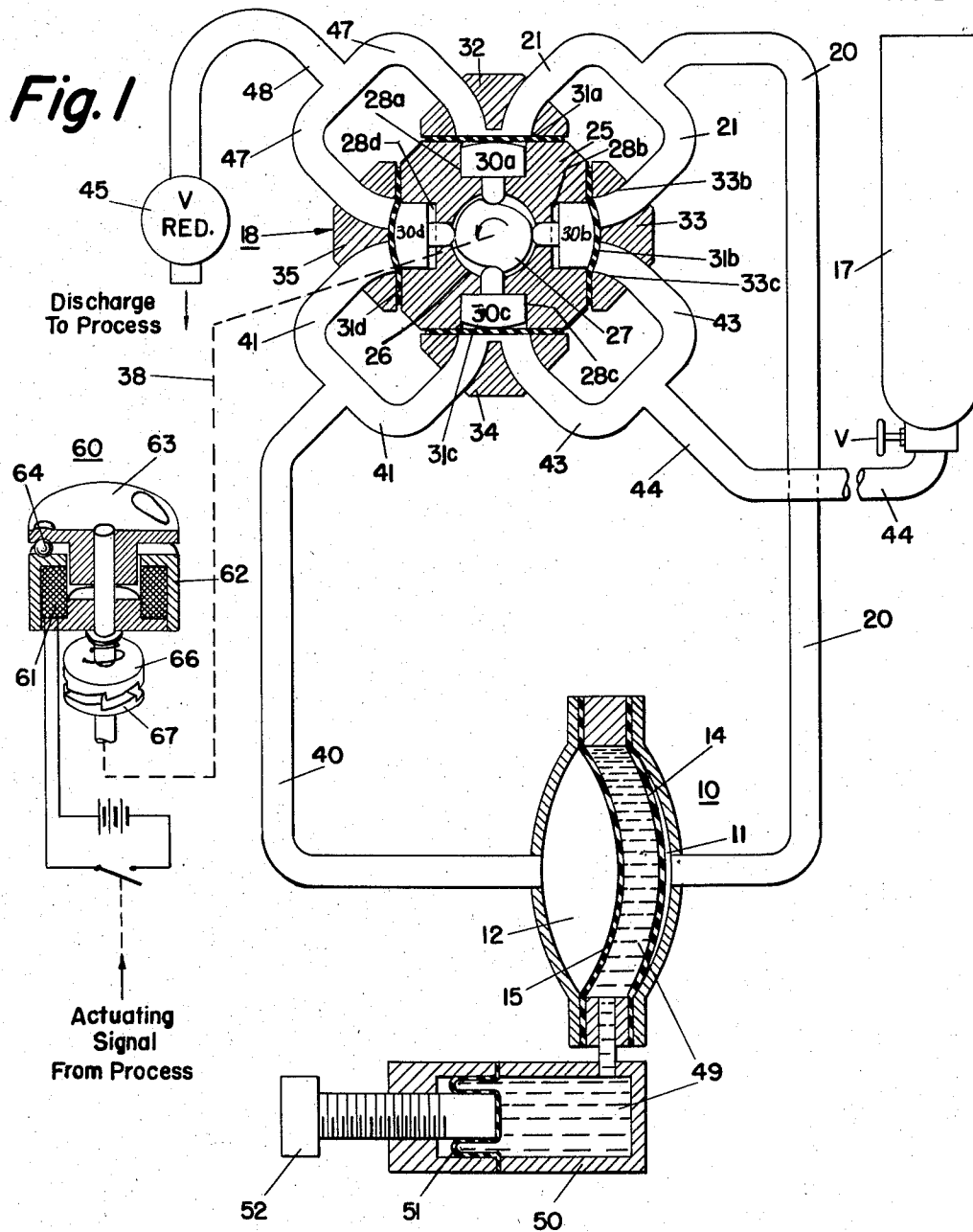


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2 Sheets-Sheet 1



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R. T. SHEEN

2,881,958

SYSTEM WITH PLURAL-WAY VALVE FOR METERING FLUID

Filed July 23, 1956

2 Sheets-Sheet 2

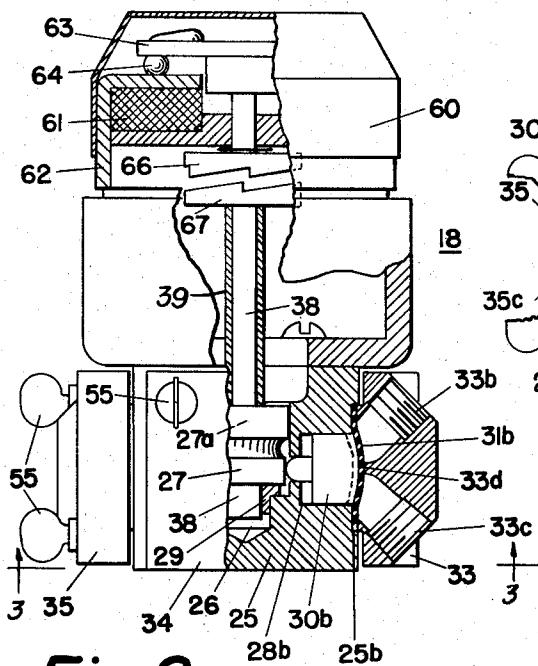


Fig. 2

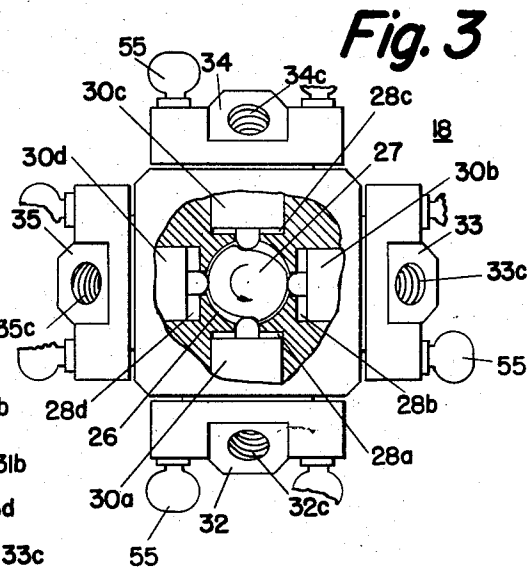


Fig. 3

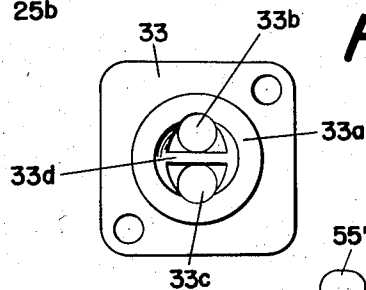


Fig. 4

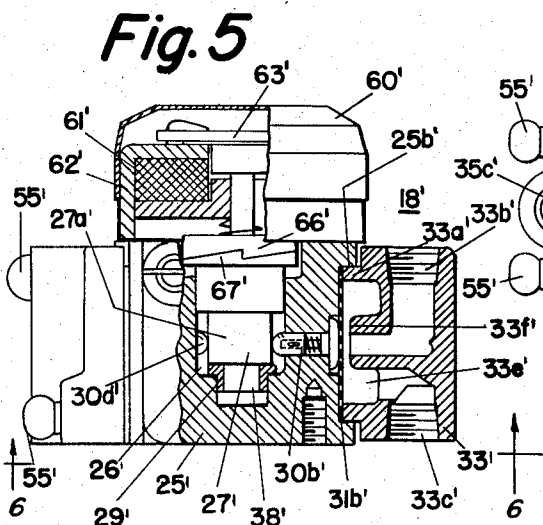


Fig. 5

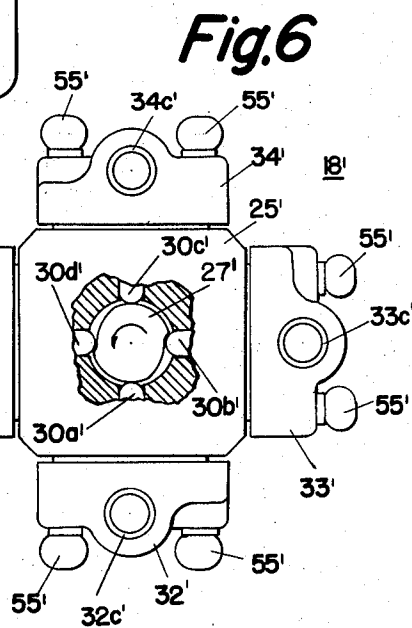


Fig. 6

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2,881,958

SYSTEM WITH PLURAL-WAY VALVE FOR METERING FLUID

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Application July 23, 1956, Serial No. 599,628

15 Claims. (Cl. 222—250)

This invention relates to a system for feeding fluid in measured quantities and has for an object the provision of apparatus of leak-proof construction including a plural-way valve of the flexible sealing type for feeding either gas or liquid in measured quantities. By reason of its construction the system is particularly suited for handling dangerous or highly corrosive fluids.

In accordance with one object of the invention, there is provided apparatus for feeding fluid in measured quantities including a pump chamber separated into isolated portions by movable means such as flexible diaphragm means. Separate flow passages are connected to the isolated portions of the pump chamber and each of these flow passages is connected with separate pairs of other chambers. A third flow passage joins a first chamber of one of the pairs with a first chamber of the other of the pairs. A fourth flow passage joins the second chambers of the pairs of chambers. Additional flow passages are connected to the third and fourth flow passages to provide inlet and discharge passages. Flexible sealing means, such as valve diaphragms, are disposed in the other chambers selectively operable to close one of the first-named flow passages with respect to the third flow passage and the other of the first-named flow passages with respect to the fourth flow passage and to open the first-named flow passages respectively with respect to the fourth flow passage and to the third flow passage and then to open the closed flow passages and to close the open flow passages alternately to admit fluid to each side of the diaphragm pumping chamber whereby as the fluid enters one side of the isolated portions of the pump chamber it concurrently pushes fluid from the other isolated portion by way of the additional flow connections for the third and fourth flow passages.

Further in accordance with the invention, there is provided the subcombination of a plural-way valve comprising a body member having a central cavity therein and a plurality of radially extending passages connecting therewith. A rotatable cam structure is disposed in the central cavity and flexible diaphragm means is disposed in each of the radial passages. There is housing structure cooperating with the body member and forming chambers for the diaphragm means, the housing structure being provided with inlet and outlet passages in communication with the chambers for the diaphragm means. A plunger is disposed in each radial passage of the body member between the rotatable cam structure and the flexible diaphragm means, each of the plungers being selectively operable by the rotatable cam structure to open and close the inlet and outlet passages in the housing structure in predetermined sequence.

For a more detailed disclosure of the invention and for further objects and advantages thereof, reference is to be had to the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a schematic view of a system embodying the present invention;

Fig. 2 is an elevational view, partly in section, showing

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one form of four-way valve similar to the one shown in Fig. 1;

Fig. 3 is a sectional view taken along the lines 3—3 in Fig. 2;

Fig. 4 is an elevational view showing the inside of one of the valve housings in Figs. 2 and 3;

Fig. 5 is an elevational view, partly in section, of a modification of the four-way valve shown in Fig. 2; and

Fig. 6 is a sectional view taken along the lines 6—6 in Fig. 5.

Referring to Fig. 1, there has been shown schematically a system for feeding measured quantities of fluid to a process embodying the present invention and including a positive displacement metering pump 10 having its pumping or displacement chamber divided into separate parts 11 and 12 by a movable member. The movable member and the pumping chamber may take various forms for example as disclosed in Bryant Patent 2,576,747. However, the movable member has been shown in this application as flexible diaphragm means. The diaphragm means may comprise a single slack diaphragm or in applications where stroke adjustment is desired it may comprise spaced flexible diaphragms such as members 14 and 15 adapted to receive a liquid therebetween to vary the volume of the separate chambers 11 and 12 in manner hereinafter to be described. The supply of fluid, either gas or liquid, may be derived from any suitable source capable of providing an inlet pressure to the system greater than the discharge pressure of the system. In Fig. 1 the supply has been shown as being stored in a container 17 with a valve V at one end thereof. The container 17 ordinarily will be disposed above the remainder of the system. Both the pump 10 and the supply tank 17 are flow-connected to a plural-way valve illustrated as a four-way valve 18 comprising four valve units.

The isolated portion 11 of the pumping chamber is directly connected to a flow passage 20 which in turn is connected to separate pairs of chambers in the four-way valve by a flow passage 21. The four-way valve is illustrated schematically in Fig. 1 as comprising a body member 25 having a central cavity 26 within which is disposed a rotatable cam structure 27. There are four radially extending passages 28a—28d disposed around the central cavity 26 and connected therewith. Each of the radial passages 28a—28d is adapted to receive a plunger 30a—30d respectively. The inner ends of the plungers are of small diameter and are adapted to be engaged by the surface of the cam 27 for reciprocating movement of the plungers within the radial passages in predetermined sequence. The outer ends of the plungers 30a—30d are shaped to engage the inner surfaces respectively of flexible sealing means or diaphragm members 31a—31d, the outer edges of the latter being adapted to be held between the common body member 25 and the individual housing members 32—35 arranged around the outside of the body member 25. The housing members 32—35 cooperate with the body member 25 to form chambers through which the liquid passes as controlled by the diaphragms 31a—31d and their respective plungers 30a—30d. Each of the housing members 32—35 is provided with inlet and outlet passages or openings respectively to interconnect each housing with its adjacent housing by way of flow passages similar to the manner in which flow passage 21 interconnects housing 32 with housing 33.

The other isolated portion 12 of the pumping chamber, Fig. 1, is directly connected to a flow passage 40 which in turn is connected to the separate chambers in housings 34 and 35 by a flow passage 41. A flow passage 43 interconnects the chambers of housings 34 and 33 and the passage 43 is directly connected to the supply of liquid 17 by way of inlet or suction passage 44. The chambers of housings 32 and 35 are interconnected by a flow passage

47 which in turn connects with a discharge passage 48 from which the liquid is delivered to its point of application.

To operate the system shown in Fig. 1, the valve V on the supply container 17 is opened and by reason of the pressure head within the container the liquid is forced through the suction line 44 into the divided flow passage 43 which interconnects the chambers of adjacent housings 33 and 34 of the four-way valve. As illustrated, the cam 27 has been rotated to a position such that the plunger 30b has moved outwardly to close the inlet and outlet passages of the chamber within housing 33 with respect to each other and thus prevents the passage of the liquid through housing 33. The cam 27 at the same time has permitted the plunger 30c to withdraw toward the center of the four-way valve, thus permitting the liquid from the supply line 44 to flow through passage 43 into the chamber within housing 34 and thence out into flow passage 41 and through flow passage 40 to the isolated portion 12 of the pumping chamber. The plunger 30d in housing 35 has moved its diaphragm 31d to close the inlet and outlet passages of the chamber in housing 35 with respect to each other and thus the fluid cannot pass from line 41 through the chamber of housing 35. It will be noted that the parts in Fig. 1 have been illustrated with the liquid entering the portion 12 of the pumping chamber and at the same time the liquid on the opposite side 11 of the pumping chamber is being forced out through the flow passage 20 into flow passage 21 and through the now open chamber within housing 32 to the flow passage 47 and thence to the discharge passage 48. It will be noted from the foregoing that the cam 27 is designed to operate the plungers in pairs with the opposed plungers 30a and 30c operating together and the opposed plungers 30b and 30d operating together. When the plungers 30a and 30c are moved to open position, the other pair of plungers 30b and 30d will be moved to closed position and vice versa. This movement takes place when the cam 27 rotates through an angle of 90°, as by actuation of a rotary valve operator 60, at which time the pumping cycle is reversed. The actuation of valve operator 60 may be controlled in various ways such as by a timer, flow meter, concentration sensing device, or other suitable measuring instrument for supplying the fluid from discharge 48 to the process in accordance with demand.

When the pumping cycle is reversed, the plungers 30b and 30d will be retracted and the plungers 30a and 30c will be forced outwardly to close the inlet and outlet passages of the chambers relative to each other within their respective housings 32 and 34. When this is accomplished, the liquid from the supply 17 will pass from flow connections 44 and 43 through the chamber of housing 33 through the flow passage 21 and the flow passage 20 to the isolated portion 11 of the pumping chamber. With entry of fluid into chamber 11 the fluid within the opposite chamber 12 will be forced out through passages 40 and 41 through the chamber in housing 35 and thence to the flow passage 47 and the discharge passage 48. The foregoing pumping action takes place by reason of the fact that there is a pressure differential or drop between the suction and discharge pressures with the suction pressure always being the higher of the two and thus providing the means for forcing a chamber full of liquid from the other side of the pumping chamber for discharge from line 48 to the point of application. The suction pressure must be greater than the discharge pressure at least by the amount of pressure drop through the system. A pressure-reducing valve 45 may be inserted in line 48 to regulate the discharge pressure so that the pressure between the pump diaphragm and valve 45 can be maintained at a predetermined value. The suction pressure or inlet pressure to the system may be very high with respect to the discharge pressure or it may be just sufficiently higher to be greater than the discharge pressure plus the drop through the system. The differential in pressure will determine

how rapidly the diaphragm or other movable member moves from one side of the pumping chamber to the other. This rate of movement can be controlled by means of the reducing valve 45 which will regulate the discharge pressure and thus control the pressure differential between the suction and discharge sides of the system.

As pointed out above, this system is particularly suited to feeding liquid in measured quantities as entry of liquid into one side of the pumping chamber will cause a chamber full of liquid to be discharged from the opposite side of the pumping chamber. The volume of the liquid to be metered may be varied by changing the volume of the pumping chamber. For example, in Fig. 1 the diaphragm means has been illustrated as a pair of spaced diaphragms 14 and 15 between which a liquid 49 may be introduced. This liquid 49 is isolated from the pumping chambers 11 and 12 and its quantity between the diaphragms 14 and 15 may be controlled. This adjustment is similar to the stroke adjustment of a pump and has been illustrated here as comprising a stroke adjustment reservoir 50 within which is disposed a movable diaphragm 51 adapted to be actuated by a stroke adjustment screw 52. When the screw 52 is moved to the right from the position illustrated in Fig. 1, liquid 49 within the reservoir 50 will be displaced, thus forcing additional liquid between the spaced diaphragms 14 and 15. This decreases the effective volume of the pump chamber and thus decreases the pump capacity. Likewise when the foregoing adjustment is reversed with screw 52 being moved to the left, the quantity of liquid 49 between the diaphragms 14 and 15 is decreased, thus effectively increasing the pump capacity. Such stroke adjustment is infinitely variable over its entire range and may be made while the pump is operating. While the stroke adjustment may be performed manually, it is to be understood that member 52 may be operated automatically in response to an actuating signal from the process similar to the arrangement for operating the four-way valve 18 but including reversible drive means, such as a motor, so that member 52 may be moved either to the right or to the left to decrease or increase the volume of the pumping chamber in accordance with demand of the process. Thus if the process requires change in metering of fluid from the system this may be accomplished not only by varying the frequency of operation of the pump but also by varying the volume of liquid to be delivered with each operation.

Having described the general operation of the system as shown in Fig. 1, reference may now be had to Figs. 2-4 for a detailed showing of one form of the four-way valve 18. As may be seen in Fig. 2, the cam 27 is disposed on a shaft 38 for rotation about a vertical axis. The lower end of the cam shaft 38 is adapted to be supported in a bearing member 29 which in turn is disposed in the lower part of the central cavity 26 in body member 25. Above the cam surface 27 is a cylindrical portion 27a which is adapted to engage the wall of the central cavity 26 and aid in maintaining the axis of rotation of cam 27 in a fixed position. The upper end of the cam shaft 38 extends above the cylindrical portion 27a through a bushing 39 and is adapted to be connected to the cam actuating device 60. The cam 27 may be rotated manually; however, it is preferably performed automatically, for example, by a rotary valve operator illustrated as device 60.

The device 60 is a rotary solenoid valve operator, which may be of the type manufactured by G. H. Leland, Inc., adapted to convert straight line pull into rotary motion through the use of the inclined plane. The coil 61 is adapted to be energized from a direct-current power source, or from an alternating-current source with a suitable rectifier, with a suitable switch in circuit with the coil to control its energization in accordance with the demand of the process to which the liquid is being fed from line 48 in metered quantities. The electromagnetic

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pull derived from the coil 61 within a case 62 operates to close the air gap between an armature 63 and the coil 61, thus moving the armature from its deenergized position of Fig. 2 to the energized position of Fig. 5. Since the armature 63 is supported by three ball bearings 64 that travel around and down in three sets of inclined ball races or grooves respectively in the case and armature plate, the armature is rotated by a cam action. The ball races determine the rotary stroke and rotation continues until the balls reach the deep ends of their respective races. To rotate the cam 27 one-quarter of a revolution for each operation of device 60, the latter preferably is provided with a stroke of about 95 degrees travel. The shaft of armature 63 is provided with a ratchet 66 adapted to engage a similar ratchet 67 carried by the shaft 38 of cam 27. When the device 60 is energized, the ratchet 66 moves into engagement with the cam ratchet 67 to rotate cam 27 through one-quarter of a revolution and reverse the pumping cycle. When the coil 61 is deenergized, a return spring is adapted to return the armature to its original position as shown in Fig. 2. It is to be understood that other suitable types of automatic valve operators may be employed.

The cam-operating surface 27 is shaped as shown in Fig. 3 to open or close the opposite plungers 30a-30d in pairs 30a, 30c and 30b, 30d. In the preferred form, the shape of the cam surface is such that the open pair of plungers is moved to closed position before the other pair of plungers is moved to open position. The sides of the enlarged outer ends of the plungers 30a-30d, Fig. 3, are adapted to engage the sides of their respective radial passages 28a-28d and thus maintain the plungers in alignment during their sliding radial movement by operation of the cam 27.

The diaphragm members 31a-31d are preferably made of a flexible material such, for example, as neoprene, and the diaphragms will normally bias the plungers inwardly toward the rotatable cam structure. Thus when the cam 27 is rotated so that a low point on its surface is opposite the inner end of one of the plungers, the plunger will be moved inwardly under the biasing force of its diaphragm and the pressure of the fluid thereby opening the inlet and outlet passages of its housing with respect to each other. With this arrangement, it is not necessary to use springs or other additional means to supplement the cam 27 in its operation of the various plungers.

The housings 32-35, Figs. 2 and 3, are adapted to be secured to the body member 25 by any suitable means and preferably by removable means, such for example, as the thumb screws 55. This construction permits the housings to be readily disassembled from the body member 25 for cleaning or replacement of the diaphragms 31a-31d when required. For example, if it is desired to change the fluid supply from one material to another, it may be desirable to clean the housings and diaphragms before passing the new fluid through the four-way valve 18.

All of the housings 32-35 are identical as are the plungers 30a-30d and the diaphragms 31a-31d and their constructions may be seen by the valve unit which includes the housing 33 shown in section in Fig. 2. The interior of the housing 33 is shown in Fig. 4 and it will be noted that there is a projection 33a extending from the inner surface of housing 33 and adapted to be received in a recess 25b in the body member 25. The diaphragm 31b is adapted to be clamped along its outer edges between the projection 33a and recess 25b and thus form a fluid-tight seal between the housing 33 and the body member 25 when the clamping members 55 are tightened. Each of the housings 32-35 is provided with inlet and outlet passages preferably threaded at their outer ends for ease in connection to the external flow passages of the system. For example, the passageway or opening 33b, Fig. 2, in housing 33 is adapted to be connected to flow passage 21, Fig. 1, and the passageway

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or opening 33c, Fig. 2, is adapted for connection with passage 43, Fig. 1. While passage 33b will operate in the system of Fig. 1 as an inlet passage and passage 33c will operate as an outlet passage, it is, of course, to be understood that if the fluid is passed through the housing in reverse direction the functions of the passages 33b and 33c will be reversed. The passages 32c, 33c, 34c and 35c for their respective housings 32-35 may be seen in Fig. 3.

In order to seal the inlet and outlet openings or passages of the housings with respect to each other when the valve units are in closed position, such for example, as sealing opening 33b with respect to 33c, the housing 33 preferably is provided with a partition 33d against the edge of which the diaphragm 31b is adapted to be pressed by movement of the plunger 30b from dotted line to full line position, Fig. 2, under the action of cam 27. The outer end of the plunger 30b has a convex shape and is adapted to conform with the concave shape of the edge of the partition 33d. Thus, the inlet and outlet passages 33b and 33c may be sealed with respect to each other along the surface of the edge of partition 33d by a relatively small amount of pressure applied to the opposite end of plunger 30d by the cam surface 27.

Another modification of the four-way valve 18 is shown in Figs. 5 and 6. The construction is generally similar to the previously described four-way valve construction 18 and corresponding parts are identified with similar reference characters. The valve body member 25' includes a central cavity 26' within which is disposed a rotatable cam 27' which is adapted to operate the oppositely disposed plungers 30a'-30d' in pairs 30a', 30c' and 30b', 30d' in manner similar to that previously described. The cam 27' has been rotated 90° with respect to cam 27, Figs. 2 and 3. Each of the four valve units of the four-way valve 18', in addition to a plunger, includes a diaphragm and a housing with diaphragm 31b' and housing 33' being shown in section in Fig. 5. The four-way valve 18' includes four housing members 32'-35', Fig. 6, each having identical construction. As may be seen in Fig. 5, the interior of housing 33' is somewhat different from that of the corresponding housing 33 in Fig. 2. The interior of housing 33' is provided with a recess or channel which cooperates with diaphragm 31b' to form a chamber 33e' which connects at one side with the opening 33c'. The opening 33b' is connected by a short flow passage to the center of the annular chamber 33e', and to seal the opening 33b' from opening 33c' the diaphragm 31b' is adapted to be pressed against the surface 33f' to close the passageway leading to opening 33b'. While either of the four-way valves 18, 18' shown in Figs. 2-4 and 5-6 is suitable, the construction shown in Figs. 2-4 is preferred as less pressure is required on the plungers to force the diaphragms into sealing engagement with their respective housings. In the modification shown in Fig. 5 the plungers, as illustrated by plunger 30b', have been provided with elongative means in the form of a coil spring. The spring will insure a positive closing of the valve diaphragm 31b' in the event of a substantial amount of wear on the cylindrical cam surface 27a' or the cam follower end of plunger 30b'. The spring is preloaded to balance the fluid pumping pressure by compression between the front and rear parts of the plunger and it is restrained by means of a pin carried by one part of the plunger and operating in a slot in the other part of the plunger. The plungers shown in Figs. 2 and 3 may be provided with a similar arrangement, and, of course, the plungers in Fig. 5 may be constructed without the elongative means similar to the plungers in Figs. 2 and 3, as the compression of the valve diaphragms will compensate for a normal amount of wear to insure a positive closing.

The flexible sealing means 31a-31b in the four-way valve 18 may take the form of flexible tubing or hose extending through the respective housing structures 32-35

and interconnecting the inlet and outlet of each of said housings. For example, in place of diaphragm 31b the flexible sealing means may be a flexible tube extending through housing 33, Fig. 1 and interconnecting passageway 21 with passageway 43. To seal these passages 21 and 43 from each other the plunger 30b will move outwardly as shown in Fig. 1 compressing the tubing against the housing member 33 similar to the manner in which the flexible diaphragm 31b is pressed against the housing 33.

From the foregoing description it will be seen that this invention has numerous advantages. The compact size and simple construction easily adapt the system to any capacity flow control problem for pumping either liquids or gases where the suction pressure is greater than the discharge pressure at least by the amount of the pressure drop in the system. The use of flexible diaphragm construction throughout the system provides a leak-proof system and avoids the need of stuffing boxes and close clearance fits.

It will be seen that a system of the foregoing type lends itself to many applications. For example, it may be used in additive injection systems wherein a predetermined volume of inhibitor is added to each container of product. The invention is also useful in bottle filling applications. For example, in a bottling system the present invention may be employed to add a controlled volume of flavoring agent to each bottle moving along a conveyor belt. As each bottle comes into place, it will trip a switch in circuit with the valve operator device 60 to actuate the diaphragm pump and valve system to deliver a controlled volume of agent to each bottle. To supply the production rate of any machine, additional pump and valve units may be arranged in parallel to pump the flavoring agent from a common storage supply to a plurality of bottles. The present invention is also applicable for accurately sampling gas from a high pressure process line. Another application to which this system is applicable is the feeding of chemicals, such as chlorine, in the treatment of a water supply. The chlorine may be metered as a liquid as described and claimed in my co-pending application, Serial No. 607,023, filed August 30, 1956, or it may be metered as a gas.

The foregoing are only a few examples of the numerous applications for the novel leak-proof system.

While there has been described preferred embodiments of the invention, it will be understood that further modifications may be made without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. Apparatus for feeding fluid in measured quantities comprising a pump chamber separated into isolated portions by movable means, separate flow passages connected to said isolated portions of said pump chamber, each of said flow passages being connected with separate pairs of other chambers, a third flow passage joining a first chamber of one of said pairs with a first chamber of the other of said pairs, a fourth flow passage joining the second chambers of said pairs of chambers, additional flow passages connected to said third and fourth flow passages to provide inlet and discharge passages, and flexible sealing means in said other chambers selectively operable to close one of said first-named flow passages with respect to said third flow passage and the other of said first-named flow passages with respect to said fourth flow passage and to open said first-named flow passages respectively with respect to said fourth flow passage and to said third flow passage and then to open said closed flow passages and to close said opened flow passages alternately to admit fluid to each side of said diaphragm pumping chamber whereby as the fluid enters one of said isolated portions of the pump chamber it concurrently pushes fluid from the other of said isolated portions by way of the addi-

tional flow connections for said third and fourth flow passages.

2. Apparatus according to claim 1 wherein said flexible sealing means comprises flexible diaphragm means and including a body member and structure cooperating therewith to form said separate pairs of other chambers for housing said flexible diaphragm means, a plurality of passages in said body member and connecting respectively with said chambers at one side of said flexible diaphragm means, said structure having inlets and outlets in communication respectively with said chambers at the opposite side of said flexible diaphragm means, a plunger disposed in each passage of said body member adjacent said flexible diaphragm means, and means for selectively operating said plunger and said flexible diaphragm means to close said inlets and outlets in predetermined sequence.

3. Apparatus according to claim 1 wherein said flexible sealing means comprises flexible diaphragm means and including a body member having a central cavity therein and four radially extending passages connecting therewith, rotatable cam structure disposed in said central cavity, said flexible diaphragm means being disposed in each of said radial passages, housing structure cooperating with said body member and forming said other chambers for said diaphragm means, said housing structure being provided with inlet and outlet passages in communication with said chambers for said diaphragm means, and a plunger disposed in each radial passage of said body member between said rotatable cam structure and said flexible diaphragm means, each of said plungers being selectively operable by said rotatable cam structure to open and close said inlet and outlet passages in said housing structure in predetermined sequence.

4. The subcombination of a four-way valve comprising a body member having four passages extending therethrough, flexible diaphragm means disposed in each of said passages, housing structure cooperating with said body member and forming chambers for said diaphragm means, said housing structure being provided with inlet and outlet passages in communication with said chambers for said diaphragm means, rotatable structure, and a plunger disposed in each passage of said body member between said rotatable structure and said flexible diaphragm means, each of said plungers being selectively operable by said rotatable structure to open and close said inlet and outlet passages in said housing structure in predetermined sequence, said rotatable structure comprising cam means shaped to open and close said inlet and outlet passages in pairs, the shape of said rotatable cam structure causing all of said pairs of inlet and outlet passages to close before one of said pairs of closed inlet and outlet passages is opened.

5. The subcombination of a plural-way valve comprising a body member having a central cavity therein and a plurality of radially extending passages connecting therewith, rotatable cam structure disposed in said central cavity, flexible diaphragm means disposed in each of said radial passages, housing structures for said diaphragm means, each of said housing structures being provided with inlet and outlet passages in communication with said diaphragm means, and a plunger disposed in each radial passage of said body member between said rotatable cam structure and said flexible diaphragm means, each of said plungers being selectively operable by said rotatable cam structure to open and close said inlet and outlet passages in said housing structures in predetermined sequence, said inlet and outlet passages being separated by a partition within each of said housing structures, and each said plunger being adapted to force its respective diaphragm means into sealing engagement with said partition to close said inlet and outlet passages in its respective housing structure.

6. The subcombination of a plural-way valve comprising a body member having a central cavity therein and a

plurality of radially extending passages connecting therewith, rotatable cam structure disposed in said central cavity, a flexible diaphragm disposed in each of said radial passages, housing structures for said diaphragms, each of said housing structures being provided with inlet and outlet passages in communication with said diaphragms, and a plunger disposed in each radial passage of said body member between said rotatable cam structure and said flexible diaphragms, each of said plungers being selectively operable by said rotatable cam structure to move said diaphragms to open and close said inlet and outlet passages in said housing structures in predetermined sequence, each said housing structure on its inner surface being provided with a recess for forming a chamber with the adjacent surface of the respective diaphragm, said chamber interconnecting said inlet and outlet passages of said housing structure.

7. The subcombination according to claim 6 wherein said recess comprises a channel surrounding the opening to one of said passages of said housing structure.

8. Apparatus for feeding fluid in measured quantities to a process comprising a displacement chamber divided into separate portions by movable means having a stroke extending alternately into each portion, separate flow passages connected to said separate portions of said displacement chamber, housing structure, each of said flow passages having a pair of connections to said housing structure, an inlet passage having a pair of connections to said housing structure, a discharge passage having a pair of connections to said housing structure, flexible means in said housing structure adapted to connect within said housing structure said inlet and discharge passages with each of said separate flow passages connected to said separate portions of said pump chamber, and means for selectively operating said flexible means alternately to seal first one and then the other said separate flow passages connected to said separate portions of said pump chamber with respect to one and then the other of said inlet and discharge passages.

9. Apparatus according to claim 8 including means for adjusting the stroke of said movable means to vary the metered volume of the fluid.

10. Apparatus according to claim 9 wherein said movable means in said displacement chamber comprises spaced flexible diaphragms, and said stroke adjusting means comprises means for introducing a variable quantity of liquid between said spaced flexible diaphragms to vary the effective volume of said displacement chamber and hence the capacity.

11. Apparatus according to claim 8 including means for controlling the rate of movement of said movable means.

12. Apparatus according to claim 11 wherein said last-named means comprises a pressure reduction valve for controlling the pressure differential at the opposite sides of said movable means in said displacement chamber.

13. In a system for feeding fluid in measured quantities, the subcombination of a four-way valve comprising housing structure, four flexible sealing members disposed in opposite pairs in said housing structure, said housing structure being provided with inlet and outlet means in communication with said flexible sealing members, movable structure disposed within said housing structure, and selectively operable means for forcing said movable structure against an opposite pair of said flexible sealing members to seal said inlet and outlet means of said housing in predetermined sequence.

14. In a system for feeding fluid in measured quantities, the sub-combination of a four-way valve comprising a body member having four passages extending therethrough, flexible sealing means disposed adjacent said body member for each of said passages, housing structure cooperating with said body member and forming inlet and outlet passages in communication with said flexible sealing means, and rotatable cam structure effective on said flexible sealing means to open and close said inlet and outlet passages in pairs, the shape of said rotatable cam structure causing all of said pairs of inlet and outlet passages to close before one of said pairs of closed inlet and outlet passages is opened.

15. The subcombination of a plural-way valve comprising a body member having a central cavity therein and a plurality of radially extending passages connecting therewith, rotatable cam structure disposed in said central cavity, a flexible diaphragm having edges disposed in each of said radial passages, housing structures for said diaphragms, each of said housing structures being provided with inlet and outlet passages in communication with said diaphragms, a plunger disposed in each radial passage of said body member between said rotatable cam structure and said flexible diaphragms, each of said plungers being selectively operable by said rotatable cam structure to open and close said inlet and outlet passages in said housing structures in predetermined sequence, each said housing being provided with a projection and said body member being provided with a plurality of recesses to receive each said projection on the respective housings and to hold the outer edges of said diaphragms therebetween, and removable means for securing said housings to said body member whereby said housings may be readily disassembled from said body member to permit access to said diaphragms for replacement or cleaning.

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